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(54) **Coating composition**

(57) An aqueous coating composition is based on a mixture of melamine-formaldehyde resin, a colloidal silica and a mono-organo trialkoxy- or trialkoxyalkoxy-silane in a solvent system consisting of water and a water-miscible organic solvent and including a curing agent. When cured the coating composition forms an abrasion-resistant coating material for solid substrates.

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Certain of the chemical formulae appearing in the printed specification were submitted in formal form after the date of filing.

## SPECIFICATION

## Coating composition

5 This invention relates to a coating composition and, in particular, to an aqueous coating composition suitable for coating substrates to render the substrates abrasion-resistant. Even though the primary objective is to obtain a coating which is extremely difficult to abrade, it is often the case that one has to balance other factors against such an objective in order to obtain a coating which is commercially acceptable. For example, abrasion-resistant coatings are available which give the ultimate in abrasion-  
 10 resistance but they are expensive and quite often do not exhibit good adhesion on solid substrates. There are other coatings, however, that have excellent adhesion on solid substrates but these lack good abrasion resistance. Other coatings lack flexibility but are economical.

Generally, the coatings available today enjoy limited commercial success because they are economical but do not have all of the properties needed for good abrasion-resistance coatings.

15 Generally good abrasion resistant coatings have been described in U.S. Patent No. 3,986,997 which consist of an aqueous solution of a colloidal silica and a hydrolyzable alkyl silane. These coatings are excellent coatings but tend to be somewhat expensive. On the other hand, there are less expensive coatings based on urethanes but they do not have good abrasion-resistant properties.

Melamines have been known for some time, mostly as crosslinking additives for urethane polymers and  
 20 other organic polymers. Just recently, the melamines have been used in larger proportions in polymeric mixtures. For example, in French Patent No. 2,194,734, alkyd resins (caster oil-modified), methacrylate/vinyltoluene copolymers with hexakis-(methoxymethyl)melamine were used as coatings to give improved surfaces.

Melamines have also been mixed with alkoxysilanes and cured onto substrates as coatings as shown in  
 25 German Patent Publication No. 2,436,191. The coatings were claimed to have good resistance to chemicals and abrasion. The melamine is claimed also to give increased adhesion compared to the same coatings without the melamine. Similar coatings were prepared using mixtures of siloxanes and alkylated melamine-formaldehyde polymers.

Several coatings have been prepared which contain, in addition to the melamine, silicates which are  
 30 prepared utilizing several different starting materials, for example, tetraalkoxysilanes shown in Japanese Patent Publication No. 80175/1973; silicic acid as shown in Swiss Patent No. 545,835; ethylsilicate as shown in Japanese Patent Publication No. 41431/1974; and silica sols as shown in Japanese Patent Publication No. 58732/1977.

None of these references, however, describe the type of coating one would expect by including both  
 35 colloidal silica and a hydrolyzable silane in a curable melamine resin. The present invention is based on such a combination.

We have discovered an economical, abrasion resistant coating that gives good adhesion to most solid substrates. The coating comprises melamine-formaldehyde resins, colloidal silica and hydrolyzable  
 40 alkylsilanes, which results in better abrasion resistance with concurrent adhesion to solid substrates than those melamine coatings containing either the colloidal silica or the hydrolyzable alkylsilane by themselves.

Thus, the present invention provides an aqueous coating composition consisting of

(A) 10-95 percent by weight, based on the weight of components (A), (B) and (C) of a melamine-formaldehyde resin;

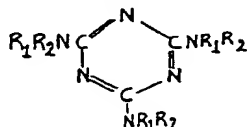
(B) 5-90 percent by weight, based on the weight of components (A), (B) and (C) of a colloidal silica;

45 (C) 0.5-10 percent by weight, based on the weight of (B) and (C) of a silane having the general formula:  $\text{RSi}(\text{OR}')_3$  wherein R is selected from methyl, ethyl, vinyl, gamma-chloropropyl, gamma-methacryloxypropyl, gamma-glycidoxypropyl and mercaptopropyl; R' is an alkyl group having 1-4 carbon atoms or an alkoxy-alkyl radical wherein the alkyl group has 1 or 2 carbon atoms;

(D) 50-90 weight percent, based on the weight of (A), (B), (C) and (D) of water and a water miscible organic  
 50 solvent selected from lower aliphatic alcohols, ketones, esters, glycols, glycol ethers and glycol esters wherein 1-70 weight percent of (D) is water and,

(E) 1-10 percent, based on the weight of (A) of a curing agent.

According to the invention, component (A) is a melamine-formaldehyde resin common to those skilled in the art. Such resins are well known in the chemical arts and do not need elaborate discussion herein. Those  
 55 resins preferred to this invention are those having the general formula:



wherein R<sub>1</sub> and R<sub>2</sub> are selected from hydrogen, -CH<sub>2</sub>OH, -CH<sub>2</sub>OR" wherein R" is an alkyl group of 1-4 carbon atoms. R<sub>1</sub> and R<sub>2</sub> may each be selected independently from the above groups and R<sub>1</sub> and R<sub>2</sub> may be the same or different. Such commercial melamine resins are, for example, a series of resins manufactured by the  
 65 American Cyanamid Company, Wayne, New Jersey, U.S.A., and sold under the tradename Cymel (Trade

Mark).

Component (A) is utilized at 10-95 percent by weight based on the weight of components (A), (B) and (C) in the composition. Preferred amounts are from 40 to 60 percent by weight.

The second component of the composition according to the invention, component (B) is a colloidal silica. These colloidal silicas have particle sizes in the range of 1-100 mμ and can be either acidic or basic. These colloidal silicas are commercially available and specific examples of such commercial colloidal silicas are those sold under the tradenames Ludox (Trade mark) AS-40, Nalcoag (Trade Mark) 1030 and Nalcoag (Trade Mark) 1034A.

The colloidal silica is present in the invention composition from 5-90 weight percent of the total solids in the composition. The preferred amount is from 30-70 weight percent.

Component (C) is a silane. Silanes useful in this invention have the general formula  $\text{RSi}(\text{OR}')_3$  wherein R and R' are as previously defined. Specific examples where R' is an alkoxyalkyl radical are  $-\text{CH}_2\text{OCH}_3$ ,  $-\text{CH}_2\text{CH}_2\text{OCH}_3$ ,  $-\text{CH}_2\text{OCH}_2\text{CH}_3$ ,  $-\text{CH}_2\text{OCH}_2\text{CH}_2\text{CH}_3$  and  $-\text{CH}_2\text{OCH}_2\text{CH}_2\text{CH}_2\text{CH}_3$ .

The silanes of component (C) are present in the composition from 0.5-10 percent by weight based on the weight of (B) and (C) in the composition. The preferred amount of silane present in the composition is 2 to 6 weight percent.

Component (D) of the inventive composition is water and a water miscible organic solvent selected from lower aliphatic alcohols, ketones, esters, glycols, glycol ethers and glycol esters. By "lower" we mean organic aliphatic alcohols having 1-4 carbon atoms. Examples of useful ketones are acetone, methyl ethyl ketone and methyl iso-butyl ketone. Examples of useful esters are ethyl acetate and methyl acetate. By the use of the term "glycols", we mean organic polymeric materials that have been prepared from alkylene oxides and which have molecular weights sufficiently low to be liquids at room temperature. Specific examples of glycols useful in this invention are ethylene glycol and diethylene glycol.

Glycol ethers are those solvents composed of low molecular weight polymeric materials described as glycols, above, which have ether end caps. Examples of materials useful in this invention are ethylene glycol monomethyl ether and ethylene glycol monoethyl ether.

Glycol esters are similar to glycol ethers but instead of ether end caps, they have ester end caps. An example of such a solvent is 2-hydroxy ethyl acetate.

Component (D) is used in this invention from 50-90 weight percent based on the weight of (A), (B), (C) and (D) components in the invention. Preferred amounts for this invention are from 50 to 70 weight percent.

The proportion of water in the aqueous compositions is dependent on the water-miscible solvents used, the type of melamine resin used and the type of silanes. Generally, the water can be present from 1-70 weight percent of the non-solids present in the composition. Thus, the water-miscible solvents present in the non-solids portion of the composition should be from 39-99 weight percent. Preferably, the non-solids portion of the composition should contain less than 50 weight percent water.

Another component of this invention, component (E), is a curing agent for the melamine.

In some cases where an acidic colloidal silica sol is used as the starting material, there is enough residual acid to give the final composition cureability. Generally, however, additional curing agents are required, especially if the end application requires accelerated cure. The usual curing agents for curing melamine-formaldehyde resins can be used in this invention. Such curing agents are for example *p*-toluenesulphonic acid; inorganic mineral acids such as hydrochloric acid; organic acids such as acetic acid; amine salts (e.g.,  $\text{NH}_4\text{Cl}$ ) and metal salts (e.g.  $\text{Al}(\text{NO}_3)_3$ ).

Generally, 1-10 weight percent of curing agent is required in this invention, based on the amount of melamine resin used (melamine solids). Greater amounts can be used but serve no useful purpose and are uneconomical. Examples of commercially available curing agents are

Catalyst 4040 (Trade Mark)	<i>p</i> -toluene sul-phonic acid	40% in isoprop- anol	
50 Cypat (Trade Mark) 296-9	Alkyl phos-phoric acid	50% in iso- butanol	50
Cypat (Trade Mark) 600	liquid org- anic acid	70% in iso- propanol	55

All are available from American Cyanamid Company, Industrial Chemicals Division, Resins Department.

The total solids in the composition according to the invention ranges from 10-50 weight percent based on the total composition. Preferred for most applications is a range of 20-35 weight percent for best results.

Generally, the manner in which the components are mixed together is not critical because the cure to achieve the final coating is not spontaneous, that is, the coatings have to be heated to cure them.

Thus, a preferred method is to add the desired silane i.e., component (C) to a given quantity of component (B) while stirring. In order thoroughly to hydrolyze the silane and make the mixture of components (B) and (C) homogeneous, the mixture is generally stirred for a few minutes to a few hours. Generally, the mixture is homogeneous in 1 hour or less. Then a second solution is prepared which contains the melamine resin dissolved by simple mixing in the desired water miscible solvents. Finally, the two solutions are mixed



Dispersion B: Cymel (Trade Mark) 303 was dissolved, with stirring, in a solvent solution consisting of 2:1 weight ratio of isopropanol and *n*-butanol to give a 25 weight percent solids dispersion.

The coating composition consisted of mixing 14:7 grams of Dispersion A and 20 grams of Dispersion B and an additional 5.7 grams of a 2:1 weight ratio of isopropanol/*n*-butanol. After thorough mixing, 0.13 grams of para-toluene sulfonic acid (Catalyst 4040 Trade Mark) was added and the mixing continued until the whole composition was homogeneous. This material was designated 1a. Similar compositions were prepared in essentially the same manner as set forth above except that the type of silane and the quantity were changed. These examples are set forth on Table I with the results from abrasion testing. The compositions in Example 1 were cured at 110°C for 16 hours after being coated onto 10.2 cm × 10.2 cm × 0.64 cm. polycarbonate panels by a flow coating technique which consisted of puddling the solution on the panel, spreading the solution to the edges and draining the excess by standing the panel on end. The polycarbonate paneling (Lexan (Trade Mark)) was manufactured by General Electric Co., Pittsfield, Massachusetts.

#### 15 Example 2

In this example, Uformite MM83 was substituted for the Cymel (Trade Mark) resin in Example 1. Therefore, for purposes of this example, Dispersion B was prepared by mixing 62.5 grams of Uformite MM83, 50 grams of *n*-butanol and 87.5 grams of isopropanol. This change in solvent weight was due to the fact that MM83 is supplied as approximately 80% solids in isopropanol/isobutanol. These compositions were coated onto polycarbonate panels as was done in Example 1 and cured for 16 hours at 110°C. The results can be found in Table I.

#### Example 3

The samples of this example were prepared as in Example 1(b) except the melamine resin was Cymel (Trade Mark) 370. The curing agent was Cycat (Trade Mark) 296-9 and the cure was 110°C for 16 hours. The results can be found in Table I.

#### Example 4

This example was carried out as shown in Example 3 except the melamine resin was Cymel (Trade Mark) 325. The results can be found in Table I.

#### Example 5

This was the same as Example 1 except the resin was Cymel (Trade Mark) 385 and the curing agent was Cycat (Trade Mark) 296-9. The results can be found on Table I.

#### Example 6

Dispersions were prepared essentially as in Example 1(b) except that the ratio of melamine solids (using Cymel (Trade Mark) 303) to the silica/silane solids was varied from 100:0 to 10:90. The total solids was maintained at 25 percent in a 2:1 weight ratio of isopropanol/*n*-butanol solvents. Catalyst 4040 (Trade Mark), was added at 1% based on the melamine resin weight. The dispersions were coated on polycarbonate panels and cured 16 hours at 110°C. The panels were abraded and the results are shown in Table II.

TABLE II

% Δ Haze on Samples, Example 6

Sample	Melamine/SiO <sub>2</sub>	% Δ Haze
6a	50:50	5.0
6b	70:30	8.6
6c	90:10	12.4
6d	100:0	18.2

#### Example 7

Example 1(b) was repeated except that the solvents and solvent combinations were changed as shown in Table III.

#### Example 8

This example was carried out to determine if the method of formulation was critical. Uformite MM83 was the melamine resin and the silane was silane II.

##### Method:

I The silane and melamine (25% in 2:1 IPA/BuOH, weight basis) were added simultaneously to the silica.

II The silica/silane were mixed together and then homogenized. The melamine was added to the silica/silane after the silica/silane was aged for one hour.

III The silica and melamine were mixed and aged one hour. The silane was then added.

In each method, the melamine/silica ratio was 50:50 and total solids was 25% in 2:1 IPA/BuOH weight ratio. Catalyst 4040 (Trade Mark) was added at 1% of the melamine weight. The materials were flow coated on polycarbonate panels and cured for 16 hours at 110°C. The results are shown on Table IV.

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#### Example 9

This example shows the effect of the concentration of curing agent versus film abrasion resistance. The results are in Table V.

This material was prepared as in Example 2(b) except that the solvent was a 50/50 weight percent mixture of isopropanol/butylcellosolve. The catalyst was Cycat (Trade Mark) 296-9 and was added at 0-10% of the melamine weight.

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Also in this example, the effect of different curing agents was tested using Catalyst 4040 (Trade Mark) and Cycat (Trade Mark) 600 which were added at 2 weight percent based on the melamine present. The samples were cured at 110°C for 16 hours after flow coating on polycarbonate panels.

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#### Example 10

The effect of varying silane content on film hardness was studied. The resin used was MM83 and the catalyst was Catalyst 4040 (Trade Mark). The preparation of the examples was carried out as in 1(b) except that the total solids was 34% in butyl cellosolve. The catalyst was added at 1% of the melamine resin weight. Polycarbonate sheets, Lexan (Trade Mark), were flow coated and cured overnight at 110°C. The results are given in Table VI.

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TABLE VI

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Sample	% silane	Type of Silane	% Δ Haze
a	0	None	9.6
b	2.49	VI	8.2
c	5.00	VI	2.6
d	7.49	VI	6.6
e	9.99	VI	8.2
f	0	None	9.3
g	2.47	III	7.0
h	5.03	III	6.4
i	7.49	III	5.0
j	10.01	III	7.4

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#### Example 11

The curing conditions of the various combinations of silanes and a melamine resin were studied. The melamine was used in a 50:50 ratio with the colloidal silica and the silanes were added at 5 weight percent of the colloidal silica present. Catalyst 4040 (Trade Mark) was added to each sample at 1 weight percent based on the melamine resin present. The solutions were coated on polycarbonate sheet, Lexan (Trade Mark), by a flowcoat method. The results are on Table VII.

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TABLE VII

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Sample	Cure Time/ Temp.	Type Silane	% Δ Haze
a	16 hr.	III	3.9
b	16 hr.	III	4.2
c	8 hr.	III	4.9
d	4 hr.	III	4.3
e	2 hr.	III	11.9
f	16 hr.	I	3.6
g	16 hr.	I	4.0
h	8 hr.	I	5.4
i	4 hr.	I	7.4
j	2 hr.	I	11.1

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#### Example 12

This experiment shows the effect of varying the type of melamine resin. The samples were prepared essentially as in Example 11. The samples were cured at 110°C. for 16 hours after coating on polycarbonate Lexan (Trade Mark) sheets. The catalyst was indicated in the table below and was used at 1% based on the

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melamine resin present. The melamine/colloidal silica ratio was 50:50 and 5% of the silane based on the amount of colloidal silicas was used.

5 Sample	Melamine	Type Silane	% Δ Haze	5
a	Cymel (Trade Mark) 303 <sup>(1)</sup>	IV	6.1	
b	Cymel (Trade Mark) 385 <sup>(2)</sup>	IV	4.0	
c	Cymel (Trade Mark) 370 <sup>(2)</sup>	IV	4.2	
10 d	Cymel (Trade Mark) 325 <sup>(2)</sup>	IV	3.4	10

<sup>(1)</sup>Catalyst 4040

<sup>(2)</sup>Cycat 296-9

#### 15 Example 13

This example was carried out to show that the source of silica for the composition according to the invention is critical. Experiments were carried out in which the silica was colloidal silica obtained according to the specification herein. Another silica was obtained by hydrolyzing ethylorthosilicate: ethylsilicate, (EtO)<sub>4</sub>Si, where EtO is ethoxy, was hydrolyzed using 100 grams of (EtO)<sub>4</sub>Si, 70 grams of isopropyl alcohol and 30 grams of 0.65 N HCl wherein the three were mixed together and stirred until homogeneous. One-half of this hydrolyzate was used fresh and the other one-half was aged for one month. The solids content of these solutions was 14.5%. These materials were designated 1a and 1b respectively. A second material was prepared from a material manufactured by the Nalco Chemical Co., Chicago, Illinois, U.S.A., and sold under the tradename Nalcoag (Trade Mark) 1034A (34% SiO<sub>2</sub> in water) by simple dilution with alcohol to 14.5% solids. This material was designated II (See below). A third material was prepared from Nalcoag (Trade Mark) 1129 by diluting to 14.5% solids. This material was designated III (see below).

42.6 grams Nalcoag (Trade Mark) 1034A	48.3 grams Nalcoag (Trade Mark) 1129		
30 32.0 grams Isopropyl alcohol	14.7 grams Isopropyl alcohol		30
25.4 grams ethanol	37.0 grams ethanol		

Note that Nalcoag (Trade Mark) 1129 is 30% SiO<sub>2</sub> in a 60:40 mixture of isopropanol and water. Cymel (Trade Mark) 303 was dissolved in butyl cellosolve at 25% solids. Using the above solutions, several samples were prepared, coated on polycarbonate panels, cured at 110°C for 16 hours, and evaluated to show the difference in the source of "SiO<sub>2</sub>". The catalyst was Catalyst 4040 (Trade Mark) and was used in 0.6 grams in each sample. The results are shown in Table VIII. Note that samples g and h fall within the scope of this invention and samples a-f do not. It can be observed that the compositions according to the invention give superior results compared to the prior art.

#### Example 14

The materials of this invention were compared with U.S. Patent 3,935,346 for abrasion resistance of cured coatings. Since the concept of adding larger quantities of melamine resins (other than crosslinker quantities) to siloxanes has been shown in the above patent, it follows that these materials should be compared to the materials of the instant invention to show the advantages of including colloidal silica in the coating formulation.

The materials were prepared following Example 1 of the U.S. Patent No. 3,935,346. The materials were coated and cured according to the patent and then evaluated by the abrasion test described in this specification. All Δ haze readings on the patented compositions were between 20 and 25 as compared to samples g and h in Example 13 above.

#### 55 Example 15

In this example, the effect of varying the ratio of melamine resin to silica content was evaluated. The silane used in all cases was CH<sub>3</sub>Si(OCH<sub>3</sub>)<sub>3</sub> and was used at 5% of the silane/silica solids. Two solutions were prepared:

Solution A was Cymel (Trade Mark) 303 diluted to 25% solids resin with 1:1 weight ratio of isopropanol/2-butoxyethanol.

Solution B was 95 parts (solids) of the colloidal silica of Example 1 and 5 parts of CH<sub>3</sub>Si(OCH<sub>3</sub>)<sub>3</sub>. After mixing, samples 2 through 6 were diluted to 25% total solids with 1:1 isopropanol/2-butoxyethanol. All solutions were catalyzed with Cycat (Trade Mark) 600 at 2% of the melamine solids weight. The solutions were well mixed and filtered through a 1.2 micron filter. Each sample was flow coated on two separate polycarbonate panels measuring 0.32 cm × 10.2 cm × 10.2 cm. that had been cleaned with hexane and

butanol and which had been heated for one hour at 120°C and cooled before coating. After coating, the panels were air dried and then heated 16 hours at 100°C. The following table shows the results of adhesion and abrasion resistance testing.

5	Sample No.	% adhesion	% Δ haze	5
	1	100	18.7	
	2	100	10.9	
	3	100	7.1	
10	4	>90	4.4	10
	5	25	7.0	
	6	(1)	(1)	

(1) the coating was flaky and could be rubbed off the panel.

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#### Example 16

Solutions were prepared similarly as in Example 1 except the type of silane used in Solution A was either VI or VII. The colloidal silica was the same as was used in Example 1. Cymel (Trade Mark) 303 was the melamine resin, the solvents were isopropanol and butyl-cellosolve and catalyst was Catalyst 4040 (Trade Mark). The quantities of each are shown in the following table and the isopropanol/butylcellosolve was a 50/59 weight ratio mixture. Panels of polycarbonate 0.32 cm. × 10.2 cm. × 10.2 cm. were flow coated after being cleaned and treated similar to the panels in Example 15. The panels were flow coated and then air dried and then cured 16 hours at 100°C. Samples 2, 4, 6, 8 are duplicate panels of 1, 3, 5 and 7 respectively.

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TABLE I

*Abrasion Resistance*

Control was uncoated polycarbonate sheet			
	Example	Silane	% Δ Haze
5	Control	---	25.0
10	1a	I	3.1
	1b	II	4.5
	1c	III	5.0
	1d	IV	4.7
	1e	V	---
15	1f	VI	1.6
	1g	VII	6.0
	1h	VIII	4.1
20	2a	I	3.0
	2b	II	2.9
	2c	III	2.3
	2d	IV	3.2
	2e	V	6.2
	2f	VI	2.6
25	3a	I	6.3
	3b	II	3.0
	3c	III	---
	3d	IV	4.8
30	3e	V	---
	3f	VI	---
35	4a	I	---
	4b	II	---
	4c	III	---
	4d	IV	2.2
	4e	V	---
	4f	VI	---
40	5a	I	4.9
	5b	II	---
	5c	III	---
	5d	IV	5.0
	5e	V	---
45	5f	VI	---

TABLE III

*Results of Abrasion Resistance Testing, Example 7*  
*(IPA is isopropanol and BuOH is n-butanol)*

5					5
	Sample	Melamine	Solvents/ ratios	Silane	
	7a	Cymel (Trade Mark) 303	IPA/BuOH 2:1	II	
10	7b	"	butylcellosolve	II	10
	7c	"	Butylcellosolve/IPA 1:1	II	
15					15
	Sample	% Δ Haze		% Adhesion	
	7a	7.4		100	
	7b	6.8		100	
20	7c	4.5		95	20

TABLE IV

	Sample	Silane	Method	Melamine	% Adhesion	% Δ Haze	
25	8a	II	1	Uformite MM83	100	5.4	25
	8b	II	2	"	100	7.3	
30	8c	II	3	"	100	7.0	30

TABLE V

	Sample	Curing Agent	%	% Δ Haze	
35	a	Catalyst 4040 (Trade Mark)	0	10.4	35
	b	"	1	6.8	
	c	"	3	7.3	
40	d	"	5	2.9	40
	e	"	5	3.6	
	f	"	7.5	4.9	
	g	"	10	4.3	
	h	"	2	6.7	
45	i	Cycat (Trade Mark) 600	2	5.0	45
	j	Catalyst 4040 (Trade Mark)	2	6.0	
	k	Cycat (Trade Mark) 600	2	4.7	
50					50

TABLE VIII

Sample	Grams IA	grams IB	grams II	grams III	
5 a	20	---	---	---	5
b	---	20	---	---	
c	---	---	20	---	
d	---	---	---	20	
e	20	---	---	---	
10 f	---	20	---	---	10
g	---	---	20	---	
h	---	---	---	20	

15 Sample	grams Cymel 303	Silane III grams	% Δ Haze	15
a	12.2	0	Coating Flaked off	
b	12.2	0	"	
c	12.2	0	15.7	
20 d	12.2	0	6.8	20
e	12.2	0.3	Coating Flaked off	
f	12.2	0.3	"	
g	12.2	0.3	1.4	
h	12.2	0.3	2.7	
25				25

Sample No.	Ratio melamine resin/ silica	Grams Sol. A	Grams Sol. B	
30 1	100/0	16	---	30
2	90/10	18	1.4	
3	70/30	28	8.4	
4	50/50	20	14.1	
5	30/70	12	19.7	
35 6	20/80	8	22.5	35

Sample No.	gms Silica	gms Cymel 303	gms/IPA Butylcellosolve	gms Catalyst 4040	
40 1	14.7	21	5.8	.1	40
2	14.7	21	5.8	.1	
3	14.7	21	5.8	.1	
4	14.7	21	5.8	.1	
5	14.8	21	5.8	.1	
45 6	14.8	21	5.8	.1	45
7	14.7	16.7	8.5	.1	
8	---	---	---	---	

50 Sample No.	gms Silane IV	gms Silane VIII	gms Silane VII	50
1	---	---	.35	
2	---	---	.35	
3	0.5	---	---	
55 4	0.5	---	---	55
5	---	---	0.6	
6	---	---	---	
7	---	1.75	---	
8	---	---	---	
60				60

## CLAIMS

1. An aqueous coating composition comprising:  
 (A) 10-95 percent by weight, based on the weight of components (A), (B), and (C) of a melamine-formaldehyde resin;

(B) 5-90 percent by weight, based on the weight of components (A), (B) and (C) of a colloidal silica;  
(C) 0.5-10 percent by weight, based on the weight of (B) and (C) of a silane having the general formula:



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wherein R is selected from methyl, ethyl, vinyl, gamma-chloropropyl, gamma-methacryloxypropyl, gamma-glycidoxypopyl and mercaptopropyl;  
R' is an alkyl group having 1-4 carbon atoms or an alkoxyalkyl radical wherein the alkyl group has 1 or 2 carbon atoms;

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10 (D) 50-90 weight percent, based on the weight of (A), (B), (C) and (D) of water and a water-miscible organic solvent selected from lower aliphatic alcohols, ketones, esters, glycols, glycol ethers and glycol esters wherein 1-70 weight percent of (D) is water and,

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(E) 1-10 percent, based on the weight of (A) of a curing agent.

2. An aqueous coating composition as claimed in claim 1, wherein (A) is present at 40 to 60 percent by weight; (B) is present at 30 to 70 weight percent; (C) is present at 2 to 6 weight percent; (D) is present at 50 to 70 weight percent and contains 50 weight percent water and, (E) is present at 1 to 10 weight percent.

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3. An aqueous coating composition as claimed in claim 1, substantially as herein described with reference to any of the specific Examples.

4. A solid article coating with an aqueous coating composition as claimed in any of claims 1 to 3.

20 5. An article as claimed in claim 4 wherein the coating has been cured.

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